This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Our Debt & Duty to the Soil:

OR,

THE POETRY AND PHILOSOPHY

OF

SEWAGE UTILIZATION.

BY

E. D. GIRDLESTONE.

BIBLIOTHECA BODLEIANA
4

"ALL DISPLAY OF LEARNING IS BUT VANITY, UNLESS IT BRINGS PRACTICAL UTILITY WITH IT."
Lord Bacon.

PRICE SIXPENCE.

SOLD IN LONDON BY HAMILTON, ADAMS, AND CO.
WESTON-SUPER-MARE: ROBBINS, HIGH STREET.
1878.

"Nature is avariciously frugal; in matter, it allows no atom to elude its grasp; in mind, no thought or feeling to perish. It gathers up the fragments that nothing be lost."

David Thomas.

"The more a man follows Nature and is obedient to her laws, the longer he will live; the farther he deviates from these, the shorter will be his existence."

Hufeland.

"Is there any pain like seeing what ought to be the best things in life turned into the worst?"

George Eliot.

Introduction.

"The ultimate aim is not Knowing, but Doing."

Aristotle.

EVERYONE who has thought on the subject at all is of opinion, I suppose, that the *Safe and Sanitary Disposal* of the dangerous constituents of Sewage is both desirable, and in some way feasible. But opinions differ widely, it would seem, as to both the practicability and the economy of their *Utilization.*

For myself, after considerable study of the subject, I am of opinion that such Utilization will ultimately be shewn to be both practicable and profitable. (Note 1.) It is not however the object of the following pages to demonstrate either of these propositions; but simply to shew with as much force as I can apply, that the *Non*-utilization of these substances is, apart from all its sanitary and economical consequences, a defiance of one of the plainest, widest, and deepest Laws of Nature,—to shew this, in the hope and belief that if it be once firmly established as a conviction in any reader's mind it will stimulate him to welcome, and deem worthy of attention, any suggestions or discoveries which may be offered for public consideration, by the many labourers in the field of Sewage-Utilization who, whether as Farmers, Chemists, or Engineers, have much greater facilities than I, a mere student, can pretend to, for the practical elucidation of this most controverted but important problem. It is only in fact to those principles connected with the subject,

> "The wonders of faithful Nature,
> "Still worked for the love of me,"

which are absolutely settled, having been in operation on this globe since a time anterior to human existence, and about which there can now be no debate, although few people seem to realize them, that I shall address myself,—

> "And then, if these be true, that other too
> "Must be a truth, a firm enduring truth,
> "Never to change, never to pass away."

The matter may seem a most repulsive one to pore over, but is not the proper law of precedence in this world

> "Not first the Beautiful and then the True;
> "But *first* the True and *then* the Beautiful?"

At all events, if any reader who has accompanied me thus far, to the brink of the mal-odorous stream, will bravely step in and endeavour to wade through it, I promise on my side—remembering the poet's apophthegm,

> "Omne tulit punctum qui miscuit Utile Dulci,"

to do my best to array the Useful in garments of Beauty, and to glorify it in turns with the Sunlight of Philosophy and the Starlight of Poetry. "All things," says the pithy Herbert—

> "All things are bigge with jest: nothing that's plain
> "But may be wittie, if thou hast the vein;"

and even "Wisdom" is at liberty, according to the Autocrat of the Breakfast Table, to appear, at times, "in slippers, and Science in a short jacket." While the transcendent importance of *facts* is attested by the greatest of modern Chemists, when, referring to his own mental history, he says "Facts saved me : I could trust a Fact," we have been recently assured by Professor P. G. Tait, that "Facts are not necessarily dry: not even if they be statistics. All depends on the way in which they are put."

The faggoted facts which in the eye of Science constitute a Law of Nature cannot with safety be ignored by a community. And if Nature has proclaimed, as I think she has to the attentive ear, as one of her imperial edicts, "Thou shalt not waste thy sewage," we cannot with impunity refuse obedience. When Julius Cæsar, reaching Rome as a conqueror, presented himself at the door of the treasury for admittance, and a certain young official was refusing to let him in, Cæsar, looking at him sternly, said, "Young man, it is easier for me to act than to speak!" and passed at once into the building. So too it is with Nature. If we will not obey her laws when we hear them, she proceeds to *act*—silently, irresistibly, and it may be, terribly. Indeed, according to Professor Huxley, "It is not even a word and a blow, but the blow first without the word. And it is left to you to find out why your ears are boxed."

I have only to add that the following pages are mainly a reprint of some letters which were contributed a few years ago to the Weston-super-Mare newspapers; but, though written for a newspaper, they were not the scribbled outcome of what Mr. Ruskin exquisitely terms "the careless incontinence of the instinct for self-expression," but were conscientiously composed; and nothing was alleged in them as fact which had not been gathered from some apparently trustworthy authority (Note 2); for, as Dryden says, "He who purposes to be an author should first be a student." Further, they would not have been reprinted now had the argument been accessible in a popular form elsewhere.

They contain little which will interest persons who are already well versed in Science; indeed their aim is expressly educational, (though they are intended for the education of adults quite as much as of youths), and the reader is throughout assumed to come to their perusal without any previous knowledge of Science; but I trust such a student will rise from it with his mind instructed and impressed by some of the most wonderful and profitable truths which have been ever penned by the Creator in his Book of Nature. In the economy of earth-knowledge I make no pretence to be a Producer; it is enough for me if I succeed as a Distributor, by a judicious arrangement in a humble shopfront commodities which others have manufactured.

I.

Borrowing from the Air.

> "The pasture and the food of plants
> First let the young agricolist be taught."
>
> *Dodsley.*

If any plant, be it the largest giant of the "forest primæval," or be it the tiniest seedling of the nursery garden, be cut down and afterwards carefully and thoroughly burnt, there will be nothing left which our eyes can trace, except a few ashes.

If we take these ashes to a chemist and ask him what they are, he will, perhaps, inform us that they are the *inorganic* or mineral elements of the plant, selected by the plant during its lifetime out of the following list:—Potassium, Sodium, Calcium, Magnesium, Aluminium, Iron, Manganese, Phosphorus, Sulphur, Flint, Chlorine, Fluorine, Bromine, and Iodine. These substances are found in different plants, and perhaps, no single plant contains specimens of them all.

Supposing, however, the plant after being cut down, is not burnt, but laid upon a bare rock and left to rot there,—if we revisit the spot after the work of decay is complete, we shall find there, as in the other case, only a few ashes, and ashes of the same description as before. The process has been slower, but the result is the same.

In either case the enquiry will naturally rise to our lips—Where is the rest of the tree or seedling? What has happened to the great bulk of it? The chemist answers—It is gone off in the shape of one liquid, namely, water, and two gases, namely, Carbonic acid and Ammonia.

Such is the end of *all* plants.

I will now leave plants for a moment in order to state the surprising but certain fact, that if the body of a *man* or of *any animal*, be it fish, flesh, or fowl, monster or animalcule, be, like this plant, either burnt or left to decay, *the result will be the same as in the case of the plant*, there will be left solid a few "ashes" (the list of plant ashes contains their names) and there will have disappeared in liquid or vapour form "Water," and in a gaseous or air-like state, "Carbonic acid" and "Ammonia."

Returning to our present subject, plants, we commonly talk of these as if they were animals; we speak of their growth, and of their being young or old, alive or dead, &c. And so too we can regard them as eating and drinking, and we can speak about their *food*.

Now there is no part of any plant but what has been made out of a plant's food. Even the seed from which it sprang was made out of its parent's food; and we may be sure that it is a rule without any exception that the substance of a plant is supplied from its food. It is a case of Hobson's choice.

But the substance of a plant, as we find when it is burnt or left to decay, consists of "Carbonic acid," "Ammonia," "Water," and some "ashes;" therefore the *food* of a plant *must* consist of "Carbonic acid," "Ammonia," "Water," and " ashes " of the same sorts.

Now there are only two sources from which a plant *can* draw its supplies, namely, the Air in which its stem and leaves are placed, and the Soil which surrounds its roots. And as a matter of fact it does help itself out of both these store rooms. Its chief food of course consists of Carbonic acid, Ammonia, and Water, and these are supplied to it in the first instance by the *air*. (Note 3.)

It has been arranged by Him in whom "we live, move, and have our being," that there should always be in the air a constantly renewed supply of Carbonic acid, Ammonia, and Water. Every time that a man or any animal breathes or sighs, a portion of each of these three ascends to heaven, and the same effect follows from the burning of every fire in the world, and from the decay of all putrefying substances. Animals by breathing get rid of Carbonic acid and Ammonia because they are deadly poisons to them, and the moisture of their breath takes with it heat which if left in the body would breed a fever. So wonderfully, so thoughtfully, so beautifully has it been ordained that the things which we breathe forth as poisons should be the very food which plants most need and seek, and should by their means be prevented from accumulating in the atmosphere to our detriment.

When these three things leave our lips they spread themselves in the broad sky, and are to be found everywhere in the air, The amount of Water (Note 4.) present in the air varies of course with the weather ; but of Ammonia there is never more, in country places, than one part by volume in 100,000 (Note 5), and of Carbonic acid about one part in 2500. (Note 6.)

Now there has been given to every raindrop, which comes from heaven to earth, a power of absorbing and taking into itself, as it is in the act of falling, a portion of the Carbonic acid and also a portion of the Ammonia which it meets with on its way. A single drop of water is able to suck into itself, without its bulk being increased by the process, a portion of Carbonic acid of its own size, as well as a portion of Ammonia 670 times as big as itself. Thus do "the clouds drop fatness" in a sense probably unsuspected by the Hebrew psalmist. (Note 7.)

An Animal is capable of absorbing to a slight extent through his skin ; but he takes his food mainly through his mouth ; and the body of a man or animal is built up partly out of the breath which goes through his windpipe into his lungs, and partly out of the solids and liquids which descend, by swallowing, into his stomach. (Note 8.) A Plant, even the largest and biggest of trees, is like an infant in this respect, that it cannot take any solid food, but must be fed with plant milk or broth—the smallest crumb of solid would choke it. Plants then never eat, but they *drink* and *breathe*. I don't mean that they have got lungs, and that we can see their chests heaving at regular intervals, but they do breathe in and breathe out aerial matter through their leaves. (Note 9.) A full-grown oak may contain 7,000,000 leaves, and through each of these leaves the oak both breathes and drinks and also perspires. Part of its *Ammonia* and nearly all its *Carbonic Acid* entered it through its *leaves*. Nearly the whole of its trunk, its branches, and the twigs on which the leaves are hanging, entered it *through* its leaves—the leaves which adorn it now, or their predecessors. They came in "with unseen feet" as Carbonic Acid, they have settled down for a time there as "heart of oak."

Water too, either passes in or passes out, according to the requirements of the plant, through the leaves. When the atmosphere is charged with moisture, and the dew is falling, the plants quench their thirst through their leaves. (Note 10.)

Nitric Acid is another substance which has been found to exist as vapour in small quantities everywhere in the air, and to be taken in by the leaves as well as by the roots of plants.

To repeat, the greater part of every plant is made out of Carbonic acid, Ammonia, and Water; and its food must, therefore, in the main, consist of Carbonic acid, Ammonia, and Water, in some form or other. These three sorts of food come to it partly through its *roots*, and partly through its *leaves*; the Carbonic acid mainly through its leaves, the Water mainly through its roots.

Each of these three dishes, and Nitric acid too, is a compound, and is made up of *two elementary* substances, thus:—Carbonic acid (a gas), of Carbon and Oxygen; Ammonia (a gas), of

Nitrogen and Hydrogen; Water (liquid), of Oxygen and Hydrogen; Nitric acid (liquid), of Oxygen and Nitrogen. Altogether there are four elementary substances comprised in this list, viz.: Oxygen, Hydrogen, Nitrogen (each of these by itself is as invisible as air), and Carbon (which is the same thing as charcoal freed from all impurities). These four elements are called the *organic* elements, because the bodies of all *organised* beings, that is, of all plants and animals, are made chiefly out of these. The fourteen *inorganic* elements which are found in the ashes of different plants were mentioned above. In treating of the relationship between plants and men, therefore, we have nothing to do with any other elements except these. In the known world there are altogether from sixty to seventy substances, called *elements*, each of which is like a single letter of the alphabet which cannot be divided by any cleverness of spelling. And the alphabet of plant-life is limited to eighteen of these letters or elements. But just as the twenty-six letters of the English alphabet, though there are only twenty-six, have been put together in so many different ways that we have got thousands of words already, and could make millions or billions more, if we wished, out of our twenty-six letters, so can our eighteen plant elements be picked over and compounded in so many different ways, that to describe the composition of a plant or of its food perfectly would be a more difficult matter than might at first seem probable, and much too difficult for me to attempt. In the *air*, however, we have only to do with *four* letters or elements, and these four appear there only in words of at most two letters each—or, as a chemist would say—in *Binary Compounds*, such as Carbonic acid, Ammonia, and Water.

That part of the food of plants which they derive from the *soil* will be treated of in the ensuing Section.

II.

Borrowing from the Soil.

> "Disposed into congenial soils
> Stand each attractive plant, and swells, and sucks
> The juicy tide—a twining mass of tubes."
>
> *Thomson.*

In the last Section I described the Food of Plants, in so far as it is drawn from the atmosphere which surrounds, and from the rain and dews which settle on, their *leaves*; and I have now to give some account of that portion of their food which is taken in by their *roots*. (Note 11).

The Soil, in which the roots of plants' are imbedded, is itself indebted to the Air for some of its treasures. Carbonic acid, Ammonia, and Water, both come to it in the "drops that water the earth," and also are absorbed by it directly from the air. And the more the soil is opened out and exposed to the air by tillage, the better able it is to take from the air the food which is placed there conveniently for its use. It has been calculated that a single acre of land receives yearly from the sky at least 30 lbs. of Ammonia and 1,000 lbs. of Carbonic acid. And as we shall presently see, these two airlike or gaseous substances, together with water, when they have entered the soil, have a very important part to play there. (Note 12).

Leaving now the gaseous and liquid portions of the soil, we will turn to its more solid parts.

And first, there is that portion of it which is commonly called "mould," and which consists of any parts of plants which have undergone decay while exposed to the action of water, air, and earth. The changing of dead plants, leaves, &c., into "mould" is always quickened by the presence of Lime in the soil; and the mould itself gets changed in due time into Carbonic acid, Ammonia, and Water, and may, indeed, be regarded as a *store* of these three things kept in the earth in a solid form ready for the use of plants, which thus may be said, like cannibals, to feed upon one another.

We have next to consider the strictly *mineral and earthy* parts of plant-food.

In the last section I gave a list of the fourteen elementary substances which are found, in one shape or other, in the ashes of plants, and must therefore have formed part of their food when they were alive. Of these, I shall at once dismiss the last two, viz., *Bromine*, and *Iodine*, because in land plants they are found very rarely, or in exceedingly minute quantities. On the others I will make a few remarks.

From the metals Potassium and Sodium are derived the *alkalies* Potash and Soda; Lime and Magnesia, *alkaline earths*, come from the metals Calcium and Magnesium; Iron and Manganese are *metals*; Sulphur and Phosphorus are *metal-like*; Chlorine, is a heavy and greenish coloured *gas*; Fluorine a yellowish brown one; Alumina (of which more below) and Flint, originate in the metals Aluminium and Silicon.

Now, there is in the air and in the soil, and even in our own bodies and the bodies of plants, an eager, quick-witted, plundering, mischief-making, restless, versatile, and powerful spirit, called *Oxygen.* (Note 13.) I have mentioned this gentleman several times before, but without alluding to these points of his character. And besides other improper practices Oxygen is guilty of, he is greatly addicted to polygamy. He insists on marrying—that is, on chemically uniting himself with—all the other elementary substances, with one or two exceptions. And it often happens, as amongst ourselves, that the offspring resulting from the marriage has very little perceptible likeness to either parent. Thus *Lime* is the offspring of the marriage of our airy friend Oxygen with a yellowish metal called Calcium; whereas if Oxygen takes the negress, Carbon (or Charcoal), to wife, their progeny is *Carbonic Acid.* Lime and Carbonic acid, then, each of them result from the union of Oxygen and some other element; they are like words made up of *two* letters each, and are therefore called Binary Compounds. But now, supposing Lime and Carbonic acid (the two children of Oxygen by his yellow wife, "Calcium," and his black wife, "Carbon," respectively) be joined in matrimony —well, they often do marry, and the offspring is what we call *Chalk.* Chalk, or Carbonate of Lime, is the result of the marriage or chemical union between Lime and Carbonic acid. Lime is an Oxide; and Carbonic acid is, of course, an acid. Now, whenever an "Oxide" marries an "Acid," the child of that marriage is called, in the ordinary nomenclature of chemistry, a *Salt.*

Chalk, therefore, is a "salt." Similarly, what we call "Smelling Salts," or, in chemists' language, "Carbonate of Ammonia," is a substance which has arisen from the union of Carbonic acid and the alkali Ammonia. Alkalies (or Oxides) and Acids (Note 14) are of natures opposite to each other, and, like some other ill-assorted couples, usually make a fine fuss when they unite; but it is absolutely necessary for the production of "Salts" that they should marry. A "Salt," in this sense of the word, has always at least *three* elements inside it; thus Oxygen, Carbon, and Calcium are all employed in the production of the "Salt" we call Chalk. A "Salt" then may be likened to a word made up of *three* letters, one of which comes twice over, as is the case in the word "food." And for this reason a "Salt" is also called a *ternary* compound. (Note 15).

In the last Section I remarked that Carbonic acid, Ammonia, Water, and Nitric acid (the four sorts of plant-food which are contained in ordinary air), are each of them made up of *two* elements, and two only; but the mineral, inorganic, incombustible, and strictly earthy parts of the soil, are found there usually, not as simple elements, and not as binary compounds, but as ternary compounds, or "Salts," each of them arising from the union of an acid with an oxide or alkali. Thus, when the liquid "Phosphoric acid" unites with the alkaline earth "Lime," the result is a substance called "Phosphate of Lime." The first part of such a name shews the acid, and the last part shews what was the alkali or "base" with which the acid united. And the *first* part of the name of a salt usually ends in "ate" or "ite." Thus, if a salt is formed with sulphuric acid, it is called a *sulphate;* with sulphurous acid, a *sulphite;* if with carbonic acid, a *carbonate;* if with silicic acid, a *silicate;* if with a humic acid, a *humate*, and so on. (Note 16).

Now there is nothing in a house more useful, more necessary, or more honourable, than the Good-wife or Housekeeper, who procures, puts by, and keeps safe the stores, and gives them out as they are required by the household. And there is no portion of the soil more necessary, more useful, or more honourable, than what may be called the Housekeeper of the soil—*Alumina.* This exemplary lady combines forethought, economy, and liberality in a most remarkable way. She is usually known under the name of *Clay* (clay consists of Alumina, with Silicic acid, and water), and I will speak of her as "clay" henceforth. The services of Clay are invaluable. She receives the Water, the Ammonia, and the different Salts which come within her reach, and she stores them up, or as much of them at any rate as her cupboard will contain. Ammonia, the most fly-away of all the things plants feed upon, is the very thing which Clay grasps most firmly. She is also very partial to Magnesia, Lime, Soda, Potash, Iron, and Manganese—all of them required for the nourishment of plants. (Note 17).

In the *mould*, then, and in the *clay*, are preserved, ready to be distributed when required, *all* the different sorts of food which plants require.

Beneath the soil, at varying depths, lies the *rock;* and the nature of the rock is not without its effect upon the soil which rests upon it, which, in many instances, is, in a greater or less degree, made out of it; and the rock forms a store-house, or *dernier resort*, for the soil. The immediate source, however, for the supply of "salts" to the plant is the *soil*.

Now, it has been before stated that plants never take in food except in a *fluid* state. The tips of the fibres of their roots consist of minute bulbs, which, from their power of sucking in liquids, have been called Spongioles, or little sponges, but which are unlike sponges in that they have no holes through which the liquids can, even with the help of the most powerful microscope, be seen to enter. Through these spongioles each plant sucks in those different kinds of food which its special nature requires, rejecting what would be hurtful to it. (Note 18).

The Mineral particles, or salts, are presented to the plant dissolved in water or vapour, as also are the Carbonic acid and Ammonia of the soil. And here what would seem to us a great difficulty had to be met, and was provided against by the Maker of the world. For several of the salts which are absolutely necessary for the nourishment of plants are not soluble in simple water, but can, at most, only be held in suspense in it. (Note 19.) Such, for instance, are the Humate of Alumina, and the Sulphate, Carbonate, and Phosphate of Lime. But it has been so ordered that these salts, though insoluble in pure water, are soluble in water which has been impregnated with Carbonic acid or Ammoniacal salts, and therefore they can be dissolved by the juices of the soil, which are rich in both Carbonic acid and Ammonia. And as the roots of the crops demand, and as the showers of rain enable, the Alumina and Mould of the soil yield up their treasured Salts, Ammonia, and Carbonic acid, to form a solution fit for the lips of plants.

If a quantity of soil be well stirred up with water, and allowed to settle, not more than two per cent. will be found to have remained in solution. This two per cent. it is which contains all the nourishment that is destined for the *immediate* support of vegetation. As this is removed from the soil, more of the fixed constituents are reduced into the soluble condition, to take its place. All nature's chemical operations, carried on in the ground, are directed to the double end of keeping a *fixed* store of nourishing material on hand, and of converting just so much of this fixed store as is required for use into a *soluble* state when it is needed.

The soil in fact is both a storehouse and a kitchen—a kitchen in which the stores received from rock, river, rain, and air are cooked into dishes palatable to plants.

As a general rule, it will be found that mineral matter abounds more in the leaves than in the stem of a plant. In the roots of the common rhubarb, and sometimes in pears, it is so abundant that when chewed they feel quite gritty.

Some plants prefer one sort of mineral food, some prefer another. The illustrious chemist, Liebig, has classified plants under titles which describe their distinctive preferences in this matter. Thus *Potash* plants he defines to be those in the ashes of which soluble alkaline salts make up more than half the weight; such plants are the beet, mangold wurtzel, turnip, and maize. *Lime* plants, such as clover, beans, peas, and tobacco, have an extra quantity of lime in their ashes. Among *Silica* (or flint) plants he places wheat, oats, rye, and barley. The *potato* belongs to the lime plants as regards its leaves, but to the potash plants as regards the part we eat.

If any one sort of ash, even that which is required in smallest amount by any particular plant, be altogether absent from a field, that plant cannot grow there. It must have *some* food of all the different sorts that it is used to. But as to the *proportions* in which it makes its dinner of its different dishes, it accommodates itself as best it can to the bill of fare presented to it by the soil in which it finds itself.

In confirmation of this statement, and because it introduces a subject profoundly interesting and suggestive in a medical point of view, I will quote from the *Food Journal* (of September, 1871), the following :—" Dr. Moffat's paper read before the British Association at Edinburgh opens a large and suggestive field. The subject was 'The Geological Systems and Endemic Diseases,' and he showed that goître and other endemic complaints were very common amongst the dwellers on the carboniferous system, whilst it was almost unknown on the Cheshire or the new red sandstone. As anæmia is a state in which there is a deficiency of oxide of iron in the blood, Dr. Moffat examined chemically the relative composition of wheat grown upon soils of Cheshire sandstone, carboniferous limestone, millstone grit, and a transition soil between the Cheshire and sandstone and other grit. He found that wheat sown upon the new red sandstone yielded the largest quantity of ash, and that it contained a much larger quantity of phosphoric acid and oxide of iron than that grown upon the other formations. It was shewn, too, that wheat grown upon carboniferous soil was deficient in phosphates and nutritive salts. The experiment was next tried of analysing twenty samples of bread, used by as many different families, living in the respective districts, and the results tallied completely with his previous observations. There was in fact a marked deficiency of the nutritive salts in the bread, owing, no doubt, to the removal of the bran from the flour with which the bread was made. The deductions which Dr. Moffat drew from these facts were, that persons of anæmic or scrofulous habit should if possible be transferred from a carboniferous to a red sandstone soil, and should be dieted as far as possible with food which contained the maximum quantity of oxide of iron and phosphates or nutritive salts." (Note 20).

The presence in soil of *Sand*, which is chiefly pounded quartz, crystal, and flint, is invaluable; for its grains being of all shapes, perfectly insoluble, and unadhesive, it tends to keep the mould, lime, and clay open for the free passage of water and the free admission of air.

The proportion the ash components bear to the whole bulk of vegetable substance is very small, varying from one to twelve per cent., but *none* of the inorganic, mineral, incombustible, and earthy particles which go to make up the ashes, and have been spoken of in this Section, can be drawn *out of the air* by the soil, however much it may crave them. And even in the richest soils they exist only in *limited* quantities. As the crops devour them year after year, *if they are never replaced*, the soil becomes poorer and poorer; and at last it may happen to the most fertile soil that it becomes barren, as has been the case in Maryland, Virginia, and North Carolina, from exhaustion of the mineral riches of the soil. Justly has it been said that "the farmer who has sold all his crops and put nothing back, will find at last that he has *sold his farm also*—sold it piecemeal." It is a system, as Liebig says, "not of farming, but of *spoliation*."

I propose in the next Section to say a few words on the different modes in which Nature and the Farmer have endeavoured to make up in part to the Soil for the loss of treasure which it sustains in the performance of its duty to the Plant,—an admission by the way on the part of the Farmer, that a Debt is owing to the Soil.

III.

Indebtedness Admitted.

"The land allowed its losses to repair,
Refreshed, and full of strength, delights to wear
A second youth, and to the farmer's eyes
Bids richer crops and double harvests rise."

Churchill.

In the last two Sections, on the Food of Plants, I have shewn that plants feed, that they get their food partly from the Air, and partly from the Soil, that the chief part of their food consists of Carbonic acid and Ammonia (two gases), and Water; that these are procurable either from the air or from the soil, and go to make up the combustible portions of their frames; that in addition to these three dishes they require those "Salts" out of which they get their incombustible "Ashes," and that these salts are both supplied, and prepared for their palate, exclusively by the Soil.

I have also shewn that though plants are constantly taking from the air some of its treasures, the *air* has the power of recovering them, whereas this is not the case with the *soil*, which, unless the farmer gives his aid, never recovers the salts of which it has been robbed.

"The fields which answered well the ancient's plough,
Spent and outworn, return no harvest now,
In barren age, wild and inglorious lie,
And boast of *past* fertility."

Such in time would be the case with all soils, unless both Nature and the Farmer united to arrest the mischief. The share of the work which *Nature* accomplishes by means of her fertilizing showers, her penetrating atmosphere, and the fall of leaves, I have already partially described. (Note 21). And I will now enumerate the ways, so far as they are known to me, in which *Man* has endeavoured to make up to the soil for what it has lost in the production of crops at his demand.

Letting a soil lie *fallow*, as was ordered to be done every seventh, and also every fiftieth year, under the law of Moses, is a primitive, though when employed alone, a not very effective method.

As an improvement upon fallowing, one Jethro Tull introduced what was called the system of *horse-hoeing* husbandry; believing that if only labour enough were given to open and stir the earth between the rows in which the seeds were sown, there would be no need of either fallowing or manuring—the air would do *all* that was required! Poor man, he did not make his fortune by his system, for in 1740 he died in a debtor's prison.

Both these are systems of "manuring from the air;" but they are alike open to the objection that, as there are no "salts" in the air, they leave that part of the creditor's demands unsatisfied.

Deeper ploughing has been tried, in the just expectation that a larger quantity of the elements of the soil, including the salts, might thus become aerated and available for the food of plants. Mr. R. L. Jones, well-known in Mid-Somerset as a farmer, in whose case practice was combined with science and crowned with success, says in a little work on Tillage, "An inch of subsoil, converted by the plough into available soil, is equal to an addition of 40 acres upon a farm of 200;"—40 additional acres, as he goes on to remark, "which will require no extra draining, fencing or manuring, in respect of which no rent will be paid, and which will be even beyond the eagle eyes of those unappeasable creatures, the assistant overseer and the assessor of taxes."

Converting a portion of the surface of the land into manure by *burning* it, is another way of making serviceable what were before unserviceable portions of the soil.

The robbery of the soil is conducted in a less monotonous and a more specious, varied, but exhaustive way, under the system called *rotation of crops*—a very good system as far as it goes, but which, like all the plans hitherto mentioned, *gives back to the soil no jot* of what has been taken from it.

I will now specify various ways in which man has *brought and added something* to the soil.

For instance, in the woods about Heidelberg, the woodmen, when they cut down a tree, take away nothing but the trunk, making bonfires of the branches and leaves, and scattering the ashes over the soil, thus giving back a part of what they took.

Ploughing in stubble and straw both lightens and enriches the soil; and the remains of a clover heap, untasted crops of turnips, and in some countries, lupines sown for the purpose, are "ploughed in" with great advantage to the soil.

It is really surprising to see what a number and diversity of things are used as *manures*—for instance, Rape-dust (the seed of the rape-plant) so good for grain crops; Seaweed, and its ashes under the name of Kelp, rich in soda (Note 22); Clay, Brick-dust, Salt, Sea-sand, Sea-ooze (by the process of "warping" (Note 23) largely employed in Yorkshire, &c.), Soot, Gas-tar, Gas-water, Woollen rags (Note 24), Horn-shavings, Sprats, Sticklebacks, Blood, Bones, Lime, Phosphate of Lime, Superphosphate of Lime (Note 25), Gypsum, Nitrate of Potash, Nitrate of Soda, Coprolites (Note 26), Guano (Note 27), Farmyard Dung (Note 28), Tea leaves, Soap suds, and the miscellaneous contents of Ashpits.

The inhabitants also of the Arctic regions of Norway have recently begun to make what they call "fish-guano" out of the heads and integuments of the millions of cods whose bodies they export as "stock-fish," as well as out of all those portions of the whale which cannot be turned to account as blubber or whale-bone. (Note 29).

Add to this the *Manuring by Stock.* The most unobservant person can hardly help noticing, in the spring of the year, in meadows which have been used during the winter as pasture, hundreds of exceptionally luxuriant patches, the cause of which may be divined at once. There is a passage in Mechi's "How to Farm Profitably" which contains convincing proof of the value of the manure derived from stock. He says:—"By asking a few questions of a farmer, I can almost immediately arrive at a conclusion as to his position, without visiting his farm. The first question would be, 'How much meat do you make per acre, over the whole acreage of your farm ;' This question has been solved by Mr. Thomas Dyke Acland, in the *Royal Agricultural Society's Journal*, vol. xi., page 666. There it will be seen that the largest corn-growing farmer in Norfolk, a most successful man, produces *four and a half score of meat on every acre* of his land. Compare this with the general average of farms in the kingdom, which certainly do not produce one score pounds of meat per acre. *The more meat you make—the more manure you produce, and the more corn you grow.* The common labourer is the best evidence on this point; with his one-eighth of an acre of ground, he knows that unless he keeps a pig to make manure he cannot expect a crop. Therefore he fats one pig, which consumes three sacks, or twelve bushels of barley meal, which at seven pounds of meal to one pound of meat, would be eighty-four pounds of meat, or four score on the one-eighth of an acre, or over thirty-two score per acre." Mr. Mechi adds, regarding his own operations, that he seldom makes less than from ten to thirteen score of meat per acre over his whole farm; and that this is the *key to good crops;* for the more meat the more manure; and the more manure the more produce. And thus, to make an *inelegant* extract from Shakspeare,

> "Our dungy earth alike
> Feeds beast and man."

Of the above-mentioned manures, some bring more of the *organic* and some of the *inorganic* elements required by the soil for the food of plants. And different manures are, of course, required by different *soils* (Note 30) and for different *crops*.

Speaking, however, of Manures generally, it may be stated, and it is most desirable to remember, that they are, as a rule, valuable in proportion as they contain *Carbonic acid*, *Nitrogen*, and *Phosphoric acid*, or substances out of which these can be got—these being the portions of any manure which are of the most importance in reference to the life of plants.

"The art of the farmer," as Mr. R. L. Jones says, "should enable him to take from the soil what is dear, to return to it what is cheap, to pay his way, and to live on the remainder; and his facilities for doing this much, while he fairly pursues his art, should call forth his grateful attention." And, as I am now aiming to shew, the utilization of sewage will give him one additional facility for doing this his duty both to himself and to his farm.

IV.

Transfer of Indebtedness from Plants to Man.

"The essence which within them lurks,
Doth help another race to be;
So God *in endless circles* works,
And thus ordains his alchemy."

Old M.S.

"Look on meat, think it dirt, then eat a bit;
And say withal, Earth to earth I commit."

George Herbert.

It would be very interesting to follow the Food of Plants as far as science has tracked its course, through root and leaf, through twig and branch and stem, and to mark the marvellous changes of nature, form, and color, to which it is subjected, and the varied uses to which it is put. But as a description of what goes on *in* plants would add no strength to the argument I am engaged in, I shall pass on at once to give some account of what is *produced by* plants.

The products of plants have been classified by science as Starch, Gum, Sugar, Wood, Gluten, Albumen, Fibrin, Tannin, Colouring matter, Bitters, Narcotics, Oils, Tallow, Wax, Resin, Gum-resins, Balsams, Camphor, Caoutchouc, Cork, Sap, Fermentive juices, Acids, Alkalies, Phosphates, Carbonates, Earths, Metallic oxides. A formidable host! Happily, however, there are only a few of these of which I shall have occasion to speak.

I have described Mr. Oxygen as a sort of Mormonite, a veritable Brigham Young in the world of matter. I have now to say a few words respecting a Lady singularly unlike Oxygen in her tastes and habits. I refer to *Nitrogen.* Nitrogen, like some coy maidens, has a singular —an almost insurmountable—aversion to the married state. (Note 31). Her desire is to spend her life "in maiden meditation, fancy-free," and she has strong convictions on the great "woman's rights" question. And when, as happens occasionally, marriage is forced upon her, she struggles persistently against the conjugal yoke, and rests not until she has obtained "a decree nisi" in the Divorce Court. It is true that Nitrogen lives a very contented life with Oxygen, when associated with him in the air (Note 32) which we breathe (nearly four-fifths of which is Nitrogen, and about one-fifth Oxygen), but then, in the air, they are *not* married (*i.e.*, chemically united), but simply communicate as brother and sister, friends and equals. (Note 33).

Into the bodies, however, of all plants and of all animals, Nitrogen is forced to enter as a portion of their food and tissues; but she forms the connection with abhorrence, and it is only the awful presence and power of *Life* that restrains her, and retains her in the body of any Organism. (Note 34.) The moment that organism, that once living plant or animal, *dies*, that moment the imprisoned Nitrogen, unless hindered by want of warmth and moisture, begins to reassert, aye, and to enforce, her right to liberty (Note 35,)—that moment too decomposition or putrefaction sets in. Putrefaction is the result of the imprisoned Nitrogen seeking to return from her enforced exile to her native sky. No substance which is altogether devoid of Nitrogen can putrefy. (Note 36).

Nitrogen, then, appears not merely to be independent and unsociable in her disposition, but even to find her joy in death and dissolution. And yet there can be no life, either of plant or animal, without nitrogen! Why so? Because, just as Fire can be supported only through the continued *destruction* of fuel, so Life is carried on amidst and by means of a succession of deaths. "Nothing," says Tertullian, "is preserved except through perishing — nothing renewed except through demolition." Without, however, going at present further into this mysterious subject, it is enough now to draw attention to a very important distinction in the products of plants and in all our food—the distinction, I mean, between the *Nitrogenous* (what contains nitrogen) and the *Non-nitrogenous* (what does not contain Nitrogen.)

Plants, then, produce *Starch*, *Sugar, and Oil,* which, when pure, are Non-nitrogenous; and *Albumen* in some form, which is Nitrogenous. These are the only plant-products with which we need trouble ourselves. The rest are produced by the plant, not so much for the food of animals as for its own use and beauty in growing, and for employment in medicine and manufactures. It would seem more natural to describe the products of plants as we see them come to table, or growing on the land,—as roots and stalks and leaves and flowers and fruits and seeds. But the other classification will suit our purpose better. I will say a few words on each of the four substances I have named.

Starch is made up of Oxygen, Hydrogen (two gases), and Carbon (or charcoal). Potatoes, rice, sago, and corn-grains (to the extent of nearly three-quarters of their weight), are made of starch. (Note 37.)

Sugar is made of the same three elements in different proportions. It abounds in the sugar cane, ripe fruit, &c. (Note 38.)

Oil is made of the same three things in different proportions again. Linseed and the olive and palm are rich in oil; and the Seeds of all plants contain some. Fat is little else than oil. Cocoa is oil to the extent of about one-half of its weight.

The above are Non-nitrogenous, and being made out of three elements each, are called Ternary compounds.

Albumen, on the contrary, is a Quaternary compound, being made out of the three elements occurring in the others, with the addition of Nitrogen. And just as the four letters a e r t may be arranged in several different ways, each arrangement making a different word, for instance, "rate," "tear," and "tare;" so may the four elements which go to make up albumen be so arranged as to make in different circumstances substances apparently different though chemically indistinguishable from each other. Thus "albumen" (or, as the name means, white of egg) is found in the juices of all plants; but earlier in the history of those plants, when it was in their seeds, it was called "gluten." The "gluten" of the corn grain becomes in the sap "albumen," and the "albumen" of the sap which courses through the stalk becomes solidified as "gluten" in the grains of corn (Note 39); as "legumin" in the case of peas, beans, and lentils; it appears also as "white of egg" in the produce of the fowl; as "casein" or the cheese principle in milk (Note 40); as the "albumen" and "fibrin" of blood; the "syntonin" or "musculin" of the lean or muscles of animals; as the "chondrin" of gristle, and the "gelatin" of skin, bones, &c. All these are called the Albuminous, Nitrogenous, or Proteid parts of the food, and of the bodies, of animals. (Note 41.)

It is to be observed that minute quantities of Phosphorus and Sulphur are *always* found in connection with the Carbon, Oxygen, Hydrogen, and Nitrogen, which go to make up these Albuminous substances, and seem absolutely essential to their existence. And indeed all, or nearly all, the eighteen elements which are found in plants are found also more or less in those products of plants which are intended to be used as the food of animals.

Now I have repeatedly stated before that the Organic, which is also the main, part of the food of plants comes *to* them in the form of such *Binary* compounds as Carbonic acid, Ammonia, and Water. But it goes *from* them to a great extent in the form of the *Ternary and Quaternary* compounds which I have mentioned as Starch, Sugar, Oil, and Albumen. The plant, then, it is clear, takes its food in a comparatively *simple* form, and out of its simple food it manufactures products which are comparatively *complex;* and which are made up of more than two elements. The plant is like a cook or chemist, and *compounds* dishes for a certain purpose. For what purpose?—For the use of animals, and especially of man.

The Body of a Man, like that of a plant, is made partly out of the air he breathes, and partly out of the food he eats. And the food he eats is made up (always excepting the contents of the salt cellar) of the plants he eats. It is true, we often call the food we are eating beef and mutton (Note 42), and by the names of various animals. But what are the bodies of sheep and oxen made of? Not counting the air they breathe, they are made out of plants only, and plants entirely. Beef and mutton are only grass and turnips and hay, &c., *in an altered state.* So that it is certain, beyond all contradiction, that the bodies of men are made up of plants and air (Note 43); and, to go a step further back, as plants are made out of soil and air, it follows that the bodies of men are made out of *soil* ("the dust of the ground,") and that *air* which is the "breath of life." And thus is shown the literal truth of that pathetic epitaph,

Earth walks on earth like glittering gold;
Earth says to earth "Ye are but mould;"
Earth builds on earth castles and towers;
Earth says to earth "All shall be ours."

For even the atmosphere is reckoned by astronomers a part of the *earth*, accompanying it in its triple motion; and, as I have shown before, there is a constant interchange of matter between the two.

And even as the bodies of men are made out of the bodies of plants, so may the bodies of plants be made out of the bodies of men. Thus a correspondent of the *Daily Telegraph*, in a letter written from Sedan, on the first anniversary of the battle fought there, said, when speaking of the warriors whose bodies lay mouldering beneath the "clusters of vividly green vegetation" that marked the battle field, that a peasant who was at work close by remarked, "They make first rate manure, do those corpses; only just look, sir, what beautiful potatoes these are!" and he held up a potato that had prospered exceedingly within two feet almost of a dead soldier. Thus is it that

The foe, the victim, and the fond ally
  That fights for all, but never fights in vain,
Are met—as if at home they could not die—
  And *fertilize the field* they each pretend to gain.

Not, as may be inferred from this argument, that the corpse form is the best form in which to turn human beings to agricultural account. And indeed, as the *Telegraph* article, referring to that letter remarked, "Surely that Sedan manure belongs to a sort of high farming which must render all profits fallacious! Why should kings be allowed to kill mankind, in order chiefly, as it appears, to grow good potatoes?"

The food of any animal then, whether we call it carnivorous or herbivorous, is, in the long run, got out of plants and air.

"Oh, all ye Green things upon the earth, bless ye the Lord; praise him and magnify him for ever."

"Oh, ye Winds of God, bless ye the Lord; praise him and magnify him for ever."

"For us the windes do blow;
"The earth doth rest, heav'n move, and fountains flow.
"Nothing we see but means our good,
"As our *delight*, or as our *treasure*:
"The whole is, either our cupboard of *food*,
"Or cabinet of *pleasure*."

V.

The Bill sent in to Man.

"Nothing on the earth is single;
All things by a law divine,
In one another's being mingle."
Shelley.

"Learn the mystery of progression duly,
Do not call each glorious change decay."
Adelaide A. Procter.

In the last section we travelled from the Food of Plants to the Food of Man, and we saw how all the solids and liquids of a man's food were got, directly or indirectly, out of the Products of Plants; these same products of plants having being derived through the agency of plant life from the food of plants, that is, ultimately, from certain portions of the soil and air.

Now if you seat a man, or any animal, in one dish of a pair of scales, putting in the other dish a weight that exactly balances him, and leave him sitting there for some time, when you go to him again you will find that his side of the scales has risen, in other words, that he is lighter than he was. If you then give him a good dinner while he is still sitting in the scales, his side will, as he eats, reach its original level, and ultimately outweigh the other side. The fact is that the life of the body as a whole is carried on through the constant perishing of individual parts ; there is a ceaseless burning and putting coals on, a ceaseless pulling down and building up. (Note 44.)

All this is the work of the ever active *Oxygen* which gets into the body with each mouthful of breath or food, and borne along upon the rapid blood-tides, visits every limb with each beating of the heart,

> —" That throbbing slave,
> " For ever quivering o'er his task,"—

that he may unrestingly carry out in all directions, from the tips of the fingers to the tips of the toes, his red radical revolutionary reforms. And the work of Oxygen, like the work of the Commune at Paris, is not effected without ashes and ruins being left about in all directions ; and the numberless streets and alleys of the body would soon become choked up and useless, unless the rubbish left there were all swept up and carried off without delay.

Well, to trace the food of man through the process of digestion in his frame, to follow it into his blood, and watch the transformation of blood into bone and muscle and fat and gristle and skin and hair and nail and nerve, and all the different tissues which make up the solids of his body ; then to note how this same blood, which brought supplies to every nook and corner, also carries off the ashes and the rubbish which it finds in any place—acting through the *arteries*, as the Purveyor, and through the *veins* as the Scavenger of the frame (just as the same cart which brings coals to our houses, is often employed to take away afterwards the contents of our ashpits) and afterwards to see how this blood is relieved of its unclean load by the joint action of the lungs, skin, kidneys, and bowels—all this would be highly interesting; but as it would add no strength to the present argument, we must, as in the case of plants, pass from the question—What goes on *in* men, to the question—What ultimately becomes of all the food consumed *by* men?

"Herb," is, as the Psalmist says, "for the use of man." With a skill beyond the chemist's art, the plant prepares out of the simple food presented to it, (Carbonic acid, Ammonia, Water, and Salts), the complex products which constitute the food of man. It yields to man, unmurmuring, its noblest parts—its fruits, which are man's food. (Note 45.) Man takes these complex fruits, the starch, the sugar, the oil, and the albumen (Note 46), manufactured for him with so much skill and forethought, and seasoned with so many spices in the shape of "salts," by the living plants. These warm him, they renew his strength, they are changed to human blood and flesh, and then, when they have served all the purposes of his body's life, he rejects them, *having pulled them all to pieces first;* and they appear in the excreted (Note 47) or waste products of his body, no longer as highly complex substances, no longer in a condition fit to support the life of an animal, but in a disorganised and ruined state—almost in the primitive condition of Carbonic acid, Ammonia, Water, and Ashes—all but ready, in fact, to be used as the Food of Plants. (Note 48.) The action of the *soil*—if the soil is allowed to act—completes the preparation, and then they *are* the very food most fit for plants. The soil supplies the last link, and the Circle of Nature is completed. Nothing has been destroyed, nothing wasted. It is merely that dust returns to dust and air to air.

Man, who has received from the plant its noblest, has nothing to yield it in return but his ignoblest. The *fruit* of a man's life, his thoughts, his works, his love, all the highest products of his life, are designed for his Maker, his neighbour, and himself. But the *Waste products*, the vile, the refuse, the rejected, he OWES to the soil from which they came, and if he pays not this debt, but casts it into the sea or river, he acts, to say the least of it, *unnaturally*—shall I not say, *dishonestly*?

There is no difficulty now in disposing of an objection which, it is anticipated, may be urged against the view herein propounded,—an objection based on the doctrine of the "Dissipation of Energy." While it will be admitted on all hands that the excreted material products, or *egesta*, of animal life must be equivalent in weight, and in ultimate elementary composition, to the *ingesta*, it may yet be maintained that in being converted from the latter condition to the former, they have been brought down from a position of advantage to one of disadvantage—a great part if not the whole of their potential energy (or energy of position) having been expended in the service of the animal, and therefore *lost*. And indeed it cannot be denied that this energy has been *expended*, and that the material molecules which leave the body are no longer reservoirs of heat or of any other form of force available for the *immediate* service of the body. Yet it does not follow from this that their virtue is for ever lost and irrecoverable. On the contrary, the whole circle facts to which our attention has been drawn goes to prove that the *egesta* of the animal, though temporarily altered, and dissipated into the Air and the Soil, may be there brought under the influence of Another Life (that of the Plant) which is *complementary* to Animal Life, and may through its reciprocating influence regain even the whole of the advantage which they had previously lost, and of the energy, available for the use of animals, which they had previously expended. These two complementary forms of Life are in fact like a swinging pendulum in its varying positions, or like the two buckets in a well, each of which, though its position is being constantly reversed, occupies at each moment, *for the purpose of that moment*, the most favourable possible position.

Let us turn our attention, before concluding, to some other points in which plants and animals seem to be *in contrast*, and intended to be each the complement or completer of the other,

> "And to be formed, as notes of music are,
> For one another, though dissimilar."

I have already spoken of the beautiful arrangement by which the Carbonic acid and Ammonia, which we get rid of in our breath, are greedily taken in by the leaves of plants, while they, on the other hand, have such a nature given them that when they are in the sunlight, they breathe out the Oxygen which our lungs most crave; (Note 49;) and I will now illustrate this further, thus:—If a number of flies be placed in a glass case (such as an aquarium) with plenty of sugar to feed on, and the case be then made air-tight, they will in a few days have so poisoned the air with their breath that they will die. But if some living plants, as well as sugar, are shut in with them, they will continue to live for months, with active appetites and in perfect health; the plants removing the Carbonic acid and Ammonia, (both of them poisonous to animals), and returning to them pure Oxygen and Nitrogen instead.

When, in one sultry night, there died 123 men out of 146 who were shut up in the Black Hole of Calcutta, they died of the poison of their own breath. But had their prison been a greenhouse full of plants and exposed to the light, their life would have been at least a little longer preserved through the life of the plants, while the plants would have thriven exceptionally well. On the other hand, were plants to change their nature and to cease from filtering our poisoned breath through their green leaves, this whole world might at last become like a vast Black Hole of Calcutta; and we might ultimately perish through the products of our lungs, &c.

One way indeed, in which an animal is known from a vegetable (a very difficult question to settle in the case of beings so small as the "Twilight monad," 8,000,000,000 of which can be accommodated in a single drop of water!) is by finding out whether it breathes *out* or breathes *in* Carbonic acid and Ammonia.

Another way of settling this question is by ascertaining whether the object has a Stomach. If it has, it is an animal; if it has not, it is a plant. Just as you might know whether a steam engine was a Stationary engine or a Locomotive by finding out whether it had a tender or not. I is a locomotive, it of course must have a tender to carry its fuel for it. So an animal, not being rooted like a plant in a nutritious soil, carries, as it were, soil about with it in its digestive organs; in which, as in the ground, the things which it has eaten are prepared for admixture with the blood, the good being passed in and the useless refused admission. For its *blood* is the true *food* of an animal; and the digestive canal, with its contents, may with some truth be spoken of as *outside* its body. Indeed, if a sea-anemone is turned inside out it will go on living as before, what was its skin becoming its mucous membrane, and what was the lining of its stomach acting as its skin.

The food of man (*i.e.*, the produce of plants) is no more fitted to be the food of plants than is the food of plants to be food of man; but plant-life is a *preparation* for animal life, and animal life is a *preparation* for plant-life. Pass food through the body of a man, and it becomes sewage; pass sewage through the soil and plants (Note 50), and it may become food. And as the *leaves* of plants do, whether men will or not, suck in from the air those Gaseous excreta of his lungs which are most poisonous to man, so is it evidently intended that the *roots* of plants should be the means of removing the poison which lurks in his Solid and Liquid excreta. That part of our waste products which passes from our lungs *is* utilized already by the beneficent ordinance of our Creator. *He has left it to us to determine* whether we will follow out the clue He has given us and utilize the other parts.

The cattle, and the trees, more just than men, do pay their debt to the soil; with what excellent results to them and us I have shewn in former sections; and indeed we all well know how, as George Herbert says,

> "Sheep eat the grass, and dung the ground for more,
> "Trees after bearing, drop their leaves for soil.

But there come into our towns and cities every day and every week, by train, by cart, by basket, provisions of various sorts, to stock the market and the shops—all of them got out of the soil. And what do most of us do with it all? We throw it away into rivers or the sea. Now, supposing it really gets safe into the sea, none of it forcing its way up through the traps into our houses, and none of it polluting the atmosphere or the river near the outfall, what will happen to it there? Will the sea utilize it? *Can* it do so? Our sewage, then, is *at the least wasted.* And when we waste sewage we waste what is as valuable, if not to us, yet to our posterity, as anything the earth contains. For what has sewage been shewn to be except the very *food* that we have eaten in another form—and that a form just suited, after passing through the soil, to become the food of plants, and so, before long, to nourish us again.

> "Open the bones, and you shall nothing finde
> "In the best face but filth."

If you add together the whole of the waste products excreted in the course of a man's life through (*a*) his lungs, (*b*) his skin, (*c*) his kidneys, and (*d*) his bowels, and if to these you add (*e*) his body, you have the whole of the food (solid, liquid, and aerial) which he has taken in in the course of his life. For all the excreta were once parts of his body, and a man's body at all times was made out of a man's food, and, as has been shewn, a m food consists of the products of plants, and the products of plants are made out of the food of plants; and therefore sewage must be made out of the food of plants; and therefore *we might naturally expect*, seeing that it consists of the same elements as the food of plants that it should be able to act as the food of plants again. Nature having completed a circle all but one link, it would be a strange thing if she had made it impossible for man to fill up that little gap! Nay, the very *disorganisation of plant-products* which is effected in the bodies of men seems to intimate a positive *intention* on the part of Nature that man should complete the circle. Moreover, as universal experience has shewn that the waste products of *other animals* are valuable as manures, we should expect, *on analogical grounds*, to find the same thing true of the waste products of man.

Here, in a nutshell, lies coiled the whole of the argument, and we can hardly help, I think, perceiving and inferring that Man does owe, and does, when he manures, in some degree acknowledge, a Debt to the Soil—a Debt which has, through his thoughtlessness, been accumulating for centuries—a debt too which threatens, if suffered to increase indefinitely, to eventuate some day in a double bankruptcy, both of the prodigal and guilty Debtor, and of the innocent but swindled Creditor. Man has in fact been slowly killing the hen that lays his golden eggs. Nature indeed from the beginning has kept whispering the Truth into the ear of Reason, to warn her of the risk; but Reason was asleep. Now at last Reason in this country has woke up and *begun* to attend to Nature's whispered warnings, and to put old Custom on his trial. If, as our Laureate alleges, even a "*good* custom can corrupt the world," what mischief may not a *bad* one work ! "Custom, though never so ancient," says St. Cyprian, "is, without Truth, an Error." "When Truth is revealed," says St. Augustine, "let Custom give place; let no man prefer Custom before Reason and Truth." Indeed, as Benjamin Franklin prophecies to us, "If you do not hear Reason, *she will rap your knuckles*." With which saying fitly comes this Argument to an

END.

Appendix.

"Visions are the creators and feeders of the world."

George Eliot.

"The greatest successes the world has ever beheld have been at one time the greatest improbabilities."

George Macdonald.

Any reader wishing to meet with a full, careful, and scientific description and discussion of the various modes of the *treatment* of sewage which have been advocated, and also of *its value, both in an intrinsic and pecuniary sense*, will find it in Professor Corfield's "Digest of Facts relating to the Treatment and Utilization of Sewage."

Some people believe and teach that no method of Utilization will ever *pay*, that is, that the net produce will never fetch in the market a price equal to the cost of production. This may possibly prove to be the truth in the *money* sense of "pay." But the question is primarily one of *wealth* and not of money, and of a species of wealth too which, while it is absolutely essential to human existence, is at the same time *not unlimited in quantity*. The dykes which keep out the sea in Holland are in themselves a source of expense and not of revenue; but yet they are valuable, nay, invaluable to the nation. And similarly it might be to the true advantage of a nation or of a town to utilize its sewage, even if the rates and taxes were increased instead of being relieved thereby.

It has also been objected on *a priori* grounds, that,—since the price to be fetched by human excreta in the manure market must, at however high a figure you estimate it, fall always greatly short of the cost of the food out of which it was produced,—therefore all attempts to utilize it *must* end in failure. But it might as reasonably be urged that it can never be worth while to collect old rags, seeing that their value can never be equal to that of new linen; and yet we know that old rags have a commercial as well as an intrinsic value, and that rag-dealers have died rich men. So too, nothing would seem more unpromising than Dead Dogs; and yet even these are turned to profitable account, and reappear among us in the shape of soap, lip-salve, perfumes, smelling-salts, jelly, gloves, and boots.

Who ranks higher *as a practical farmer* than Mr. J. J. Mechi? And he (in 1877) writes as follows on this subject:—"Where there's a will there's a way. It is the want of will and belief, that keeps Sewage in our rivers instead of on the land. I call it National Suicide." And again, "It is not only the duty, but the interest of landowners and tenants to receive and pay for such a valuable and effective producer of human and animal food. I deny that farmers do not desire to have it, and are not willing to pay for it on delivery. I wonder that any one can doubt it, when we know that its application to land very soon increases the crops, raises the rent, and consequently the fee-simple value of the land which receives it. Look at the Craigentinny meadows at Edinburgh; in their natural condition much of them was a sandy waste; now the average annual letting for six months of the year is at £22 10s. per acre, by public auction."

A great practical difficulty however lies in the existence, or at any rate the construction, of our Towns and Cities. When we look only at the dark side of the picture most of them actually present, we are inclined to apply to them Carlyle's description of London as "that monstrous tuberosity of civilized life;" but if,

> "Into the great *Might-have-been* upsoaring, sublime, and ideal,"

we contemplate the potentialities, and the brighter aspects, of City life, we are ready to exclaim with Dr. Guthrie, "I bless God for Cities!" Were a city properly planned and constructed, with due regard to all the physical, moral and social requirements of its inhabitants, or were our existing ones reconstructed on such principles, the profitable disposal of their Sewage would not be, as now, a problem of appalling difficulty, and we might accept the philanthropist of Edinburgh rather than the philosopher of Chelsea, as the exponent of our sentiments.

Notes.

"It is some satisfaction to a writer to know that he has written anything worth stealing."

F. Mason, D.D.

NOTE 1.

I cannot forbear mentioning a single fact in proof of the *profitableness*, in every sense of the word, of Sewage-Utilization, because it is one of which I happen to have had eight years' official cognizance and experience. I refer to the treatment of excretory and refuse matters at the West of England Sanatorium, near Weston-super-Mare.

This is a Convalescent Home, which contains, on the average, about 50 inmates. It is built on a floor of concrete, resting on a soil which is composed chiefly of sand. Its garden abuts upon the sea shore. The garden is of such moderate dimensions that the whole of it, both kitchen and ornamental, is kept in order by one man. Yet in this garden are grown (except in very dry seasons) nearly the whole of the vegetables consumed by the hungry convalescents. Formerly a roadside inn occupied the spot, and the garden was then almost wholly unproductive. Whence the difference? The present productiveness of the garden arises from the fact that the institution *pays its Debt, and does its Duty, to the Soil—everything, solid and liquid—being put into the garden there*. Not a single drain pipe leaves the premises; nor is there a water-closet upon them. The utilization is effected almost entirely through the use of *Moule's* Dry-Earth System, the trifling remainder being treated by Tank-storage and Irrigation. Yet the *Medical Report* for 1871-2 says, "The system of Earth-closets which has been in use at the Sanatorium from the commencement, works admirably, and we can report in the most unqualified terms of its complete success in both a sanitary and a horticultural point of view." And again, in the Report for 1876-7, the Visiting Medical Officer remarks, "The Earth-closet system still continues to give satisfaction."

NOTE 2.

I am particularly indebted to Dr. R. J. Mann's "Guide to the Knowledge of Vegetable and Animal Life"—an unpretentious little school-book, which for simple and masterly exposition of its subject is beyond all praise. It is like a well-lighted and gently-graduated staircase, the summit of which commands a clear and comprehensive view of Biological scenery. From the newspaper reports of Professor Dewar's Royal Institution Lectures (1878) on Vegetable Physiology, I have gleaned some of the statistical curiosities embodied in these Notes.

NOTE 3.

Some idea of the extent to which the atmosphere is capable of supplying plant-food on an emergency, may be gathered from the fact that when lava has been thrown over the earth by the action of volcanoes, vegetation, in the form of wild fig trees, &c., begins to appear, almost as soon as the lava has cooled, in the crevices of the lava itself, wholly destitute as that substance is of all mould or vegetable ingredients.

NOTE 4.

The average amount of water suspended as invisible vapour in the air is estimated at about 1¼ per cent.

NOTE 5.

The sharpness which we observe in smelling salts, hartshorn, or sal volatile, is due mainly to the imprisoned Ammonia making its escape. Hartshorn is merely Ammonia dissolved in water.

NOTE 6.

The gas which is in such a hurry to escape when a soda-water bottle is uncorked is Carbonic acid. It has been calculated that the coals burnt in England alone yield 200,000,000 tons of Carbonic acid annually. A healthy man by breathing alone parts daily with about 8 oz. of Carbon; and altogether he excretes in the course of a year Carbonic acid enough to produce 2 cwt. of Carbon.

NOTE 7.

"In every drop of water," says Stevenson Macadam, "there is a little atmosphere." In the world of mind we meet with parallel phenomena; thus, for instance, in the "Autocrat of the Breakfast Table"—a book repeatedly referred to in this pamphlet, we find the pages gifted, like drops of rain, with a strange power of absorption, for, after being filled with wit, they seem to have taken in as much wisdom as wit, and again as much poetry as wisdom, and all without increasing their original dimensions.

NOTE 8.

The quantity of chemically dry, solid matter which a man of average size and activity must take in daily by his stomach, if he is neither to gain nor lose in weight is, according to Professor Huxley, about 8,000 grains; his blood also absorbing through the agency of his lungs 10,000 grains of Oxygen, that is, about one-fifth part of the total volume of Oxygen, or one twenty-fifth part of the total volume of Air, which he inhales.

NOTE 9.

Plants breathe *out*, as well as breathe *in*, through their leaves. They breathe out pure Oxygen and Nitrogen when exposed to sunlight; and thus confer a double benefit on man—they remove the Carbonic acid and Ammonia which poison him, and yield those elements of air which constitute pure breath. It would take an acre of vegetation to appropriate and store up the quantity of Carbonic acid evolved by eleven men. The average thickness of the English coal-field being reckoned at 16 ft., it is calculated that not less than 20,000 years of vegetation would be required to produce now an equivalent amount of carbon on the same area. Wood and coals have been called "bottled sunshine;" but it has been found by experiment that a growing forest is able to appropriate and "bottle" only about one part in fifteen hundred of the radiance shed upon upon it.

NOTE 10.

Three-and-a-half pounds of water are required for the production of sixteen grains of corn, Plants *perspire* (more elegantly *transpire*) largely, when they have a moist soil to drink from, and a dry air surrounding them. An ordinary sized cabbage perspires to the extent of about a pint of water a day. So does a sunflower with a leaf-surface of 5,616 square inches. An acre of grass has been found to part with water at the rate of 6,400 quarts in the same time. A field of wheat between April and July gives out water enough to cover the land on which it grows to the depth of nine inches. Nor will this amount seem surprising when it is borne in mind that some plants have as many as 160,000 perspiration pores on every square inch of the underskin of their leaves. Most of this water usually enters the plant through the roots, but part of it through the leaves; the maximum speed of the ascending current being twenty-four inches per hour. It has been found by experiment that one grain of *organic* matter enters the plant and remains to form part of its substance for every 200 grains of perspiration which pass from it, and one grain of *inorganic* matter for every 2,000 grains of perspiration; so that the amount of this outflow becomes an index of the amount of nutrition.

NOTE 11.

A laurel, with 3,000 leaves, comprises no less than ten square yards of leaf-surface. Root-spreading plants with little foliage, are mainly *soil-feeders;* and leaf-spreading plants with scanty roots, are mainly *air-feeders*.

NOTE 12.

Ammonia, which consists of the two elements, Nitrogen and Hydrogen, comes into existence only through and during the putrefaction of vegetable and animal substances. No human cook or chemist can take the two elements and *make* Ammonia out of them.

The very opposite is the case with Carbonic acid. We can take Carbon and Oxygen, the two elements of which it consists, and make them up into Carbonic acid at will. We do so every time we light a fire or candle. But no art of man can *unmake* Carbonic acid and separate it into Carbon and Oxygen. Only the leaves of plants can do this.

Water, on the other hand, can be either composed or decomposed by the chemist.

NOTE 13.

It is computed that one half of the weight of the globe is due to Oxygen.

"The Omnipresent, said a Rabbi, is occupied in making marriages. The levity of the saying lies in the ear of him who hears it; for by marriages the speaker meant all the wondrous combinations of the universe whose issues make our good and evil."—*Daniel Deronda.*

NOTE 14.

When Oxygen unites with Carbon, Nitrogen, Phosphorus, Sulphur, or Silicon, the result of the union is called an *acid.*

Fluorine or Chlorine sometimes take the place of Oxygen in forming Acids.

When Oxygen unites with Potassium, Sodium, Calcium, Magnesium, Aluminium, Iron, or Manganese, the result of the union is called an *oxide.*

Ammonia, being alkaline in its nature, may be classed for the present purpose with the oxides, though containing no Oxygen.

NOTE 15.

"In the modern chemistry, the word *Salt*, although still used as a descriptive name, has no technical meaning."—*Professor J. P. Cooke.*

NOTE 16.

Rock-crystal, amethyst, topaz, agate, and opal, are forms, more or less impure, of Silicic acid.

NOTE 17.

Alumina is capable of acting either as an acid, or an alkali, according to circumstances. The ruby, emerald, and sapphire, are nearly pure Alumina. Alumina, like other good housewives, is not a gad-about, but attends to her duties at home, in the soil; seldom leaving it even to be embodied in the tissues of a plant.

NOTE 18.

At least one instance has been observed of plants absorbing Lead. Grass had grown upon land over which the refuse of lead mines had formerly been thrown; and cows having been pastured on that land, lead was discovered in their milk, and the symptoms of lead poisoning in those who had drunk it.

NOTE 19.

Carbonate of Soda stirred up in water is *dissolved*, as sugar is or common salt; but Carbonate of Lime (*i.e.* chalk) will not dissolve in water. It can be kept *suspended* in water by stirring; but when the vessel is still, it will gradually fall to the bottom, leaving the water clear, which would not be the case if it were in *solution*.

NOTE 20.

The late Dr. Lankester, the well-known coroner and sanitarian, and a writer on both Human and Vegetable Physiology, states, in a little work called "Good Food"—published in 1867—that Mr. Julius Schweitzer, the chemist, has at his suggestion, manufactured a salt called "Dietetic Salt," which contains common salt, combined with the various other mineral substances found in the human body.

NOTE 21.

It is worth noting how Nature both assists in the preparation of soil and supplies a species of manure, through the operation of *earth worms.* The earth worm inhabits holes which it makes by eating its way through the mould, feeding partly on organic, and partly on mineral substances, such as clay, sand, and grit. The indigestible portion of this strange diet it throws out either upon the surface above it or else into one of its own or some other worm's deserted galleries, in those familiar heaps which are called worm casts. Sometimes there is scarcely a space of two inches square without a little hillock of these cylindrical castings. As the worms desert their old burrows the soil sinks in and fills them, and by this means the vegetable mould is carried downwards and the mineral matters upwards, and the two sorts get constantly minced and mixed together in a manner which is agreeable to the roots of plants.

NOTE 22.

Soda is either a *vegetable* or a *mineral* alkali, derived from sea plants and salt. Potash is a *vegetable* alkali, derived chiefly from land plants. Ammonia is an *animal* alkali, derived chiefly from animal substances. Potash and Soda are *fixed* alkalies; Ammonia is a *volatile* alkali.

NOTE 23.

Warp, or sea Ooze, abounds at the mouths of friths, estuaries, &c.; on the banks of the Humber, for instance. It is especially rich in inorganic matter. The tide is admitted over the land which is to be "warped" (and which has previously been embanked) through flood gates; and each tide leaves on the average one-eighth of an inch thick of fertilising mud. The inundations of the river Nile produce their well-known effect on the same principle.

NOTE 24.

Connected with flocks and wool there is a very valuable produce, rich in all the elements of manure, which is often neglected as far as agriculture is concerned. Wool loses about forty per cent of its weight by its first washing. French agriculturists know the value of this wool sweat as manure; and it is calculated that enough of it is produced and used, annually in France, to manure 370,000 acres of land.

NOTE 25.

The Superphosphate of lime differs from the Phosphate in having a greater proportion (probably double) of phosphoric acid. The process by which the superphosphate of lime is got out of bone is the cause, according to Mr. Pusey, of the most important saving which was ever held out in the use of manure.

NOTE 26.

Coprolites are the fossil fæces of extinct animals, and about twenty-six per cent. of their substance is phosphoric acid. They were first found in 1843 by Professor Henslow, in Suffolk. They are intensely hard and difficult to grind, and when ground have to be dissolved in sulphuric acid. *Apatite*—a mineral imported from Norway—is also rich in phosphate of lime.

NOTE 27.

Guano, the most valuable of manures, contains abundance of Lime, Phosphoric acid, Nitrogen, &c. It is the excrement of sea-fowl, and is found, in accumulations of ages, along the coast of Peru (in one island, 200 feet thick), and in Africa—the dryness of the atmosphere allowing the heat of the climate to produce a coating of the surface (pure muriate of ammonia), which preserves its virtues as a manure.

NOTE 28.

Farm yard dung differs in its properties, according to (1) the organization, (2) the mode of employment, and (3) the food, of the animals which produce it. The manure of *fattening* stock is the best.

NOTE 29.

See "Through Norway with Ladies," by W. Mattieu Williams.

NOTE 30.

Soils have been classified under eight heads: as Sandy, Gravelly, Clayey, Chalky, Peaty, Alluvial, Marshy, and

Loamy. The character of a soil depends greatly upon its geological origin; and this, owing to the strata of the rock often coming to the surface obliquely, may differ in different parts of the same field, as has been shewn by Mr. R. L. Jones, and illustrated by diagrams, in that pamphlet of his on Tillage, to which I made reference above.

NOTE 31.

Nitrogen is never found existing naturally, *i.e.*, without man's agency, in the inorganic world, except in four salts, of which one is "Nitre" or "Saltpetre."

NOTE 32.

A singular proof of the unchanged nature of the atmosphere has been given by certain sealed jars, containing air only, which have been discovered among the ruins of Pompeii, after being buried there 1800 years; the air in which, on examination, has been ascertained to be in its composition exactly like the air of the present day.

NOTE 33.

In Nitric acid we see the result of the chemical union, or marriage, between Oxygen and Nitrogen. Whenever a flash of lightning passes through the air, one effect of the electric action is to bring small portions of the Oxygen and Nitrogen previously consorting in only *mechanical* companionship, into *chemical* union under the form and name of Nitric acid—the nuptials being celebrated with a peal, not of bells, but of thunder.

NOTE 34.

Anything is called an "Organism" or "Organised" which has *organs*; that is, which is made up of different parts that are intended to serve *different* purposes, and yet to work together harmoniously for the good of the living whole to which the different parts belong.

A plant or animal answers this description, and therefore is an organism; a stone is not. It is not true of a stone that different portions of it have diverse duties assigned to them by Nature.

NOTE 35.

Nitrogen, with all her objection to union in solids and semisolids, make an exception in favour of the gas Hydrogen, by combining with it and so forming the volatile and freedom-loving Ammonia. But this union is never effected, except when the atoms of the two gases happen to be *in the act* of disengaging themselves from some perishing organism at the same instant and in the same neighbourhood.

NOTE 36.

No substances can *Coagulate* except such as contain Nitrogen. The coagulation of a nitrogenous substance may be effected in three ways—(1) by the addition of an *acid*, as when rennet curdles milk; (2) by the action of *air*, as when blood clots; (3) by the action of *heat*, as shewn in the setting of the white of an egg.

Nor can anything which does not contain Nitrogen act as a *Ferment*. Thus we find Nitrogen in yeast. And when milk turns sour of itself it is through some of the Nitrogenous part of it (the "casein") changing to a "ferment," which "ferment" then changes the sugar of the milk into an acid (lactic acid), which acid coagulates the rest of the "casein" and separates it from the whey as curds.

But neither putrefaction nor fermentation can take place except a certain amount of moisture and warmth be present. In Alpine snows the bodies of travellers have been found frozen in the snow and ice, dry, crumbling but not putrefied, after the lapse of more than 20 years.

NOTE 37.

The Starch used by the laundress is got chiefly out of potatoes and wheat. The Starch part of our food gets changed, by the saliva and other juices of the body into first a sort of gum, and then a sort of melted sugar—in which state it is ready to enter the blood.

NOTE 38.

Grape sugar (such as starch turns to in our bodies) and the ordinary *cane* sugar, differ from each other in respect of the proportion of carbon they respectively contain. By a species of *decay*, sugar is changed into *alcohol*, and if the process is carried further, we arrive at *ether*.

NOTE 39.

The "gluten" is that *glutinous* part of corn grains which remains in the mouth after long chewing. About one-sixth of each grain of wheat is gluten.

NOTE 40.

Milk contains a species of Sugar (which may be regarded as starch a little changed), besides Oil, Albumen, and Salts—a little in fact of all the things required for the food of an animal. Few, if any, articles of food come to the table which are wholly devoid of Albumen in some shape. But in some, as in the potato and arrowroot, it is found in very small proportion.

NOTE 41.

Nitrogen enters into all the tissues of the body with very trifling exceptions, and is one of the components of the Urea which is found more or less in all its excretions. Yet, as Dr. Edward Smith says, "the emission of Carbonic acid, and not of Urea, is the true measure of muscular exertion;" both the Warmth of the body and its Labour being supported mainly at the expense of its *Non*-nitrogenous constituents. As regards our bodily Heat, as much (according to Dr. R. J. Mann) is produced annually in the blood of a full-grown active man as would be sufficient to change eleven tons of ice into boiling water. And it follows from some interesting calculations made by Professor Haughton, that, if a man's food be divided into thirty-one equal parts, Twenty-four of them go to keep up the *Warmth* of the body, Four to carry on the work of *Circulation and Perspiration*, while the remaining Three are expended on muscular or other *Labour*. The same authority estimates the "daily labour" of a man at 353·75 foot-tons—which is the exact equivalent of the work done by a man of 150 lbs. weight climbing through one mile of vertical height. "The human body," according to Sir William Gull, "is of all known things in the world the most economic," *i.e.*, it gets a larger proportion of force out of the material it consumes than does any machine of man's contrivance.

NOTE 42.

It is seriously argued at considerable length by Dr. Mapother, in his Lectures on Public Health, that we should get much more nourishment out of our meat if the animals were so killed and cooked as to *retain the blood*—a great part of the "salts" in the body of an animal being lost with its blood.

NOTE 43.

It may be objected to this sweeping statement that the bodies of *Fishes* are not made out of Plants. And doubtless many species of fishes feed entirely on fish, and others upon crustacea, mollusca, and so forth. But all those aquatic animals, on which other species feed, but which are themselves neither carnivorous, nor piscivorous, must be, I suppose, herbivorous. It is only in poetry that even chameleons "feed on light and air." Mr. W. Mattieu Williams, in his work already referred to, says: "The pasturage supplied by fertile submarine meadows of moderate depth, is likely to afford the primary food of the multitude of creatures which the vast shoals of voracious bottom-swimming fish must consume;" and George Herbert's saying about fishes is not less credible because it is in verse:—

"The great prey on the less, *they on the weed.*"

NOTE 44.

It used to be said that in the course of seven years every particle of the body was renewed. This is highly improbable as regards bone, which wastes and is renewed at a much slower rate, while the softest portions of the body are undoubtedly re-made much oftener than once in seven years—some perhaps once in a few days. "Every meal is a rescue from one death, and lays up for another; and while we think a thought we die," says Jeremy Taylor. "It is true of the brain, and all our other organs," says O. W. Holmes, "that they can only live by dying. We must all be born again, atom by atom, from hour to hour, or perish all at once beyond repair." You read not, and I write not, this line, except at the cost of human blood, and through the consumption of our bodies' tissues. Indeed, "the most vigorous health," to use the words of Professor Sydney Ringer, "is best maintained by a rapid construction and destruction of tissues within certain bounds, provided these two processes are fairly balanced."

NOTE 45.

There is reason to believe that plants *excrete* through their roots, as well as perspire through their leaves, (and the condition of the water in a vase where flowers have been for some time kept favours this notion); but the whole subject is very obscure.

NOTE 46.

The essential sameness of the various forms of Albumen is strikingly shewn in the fact that a species of *cheese* made out of *peas* is sold in the streets of Canton under the name of "taofoo," and is a great favourite with the lower classes there; so like in its nature is the "casein" of animal milk to the "legumin" of the vegetable.

NOTE 47.

A product (*e.g.*, saliva or bile), which is separated from the blood by the action of a gland for the internal service of the body, is said to be *secreted*, and is called a "secretion;" but if like perspiration, it is separated from the blood for the purpose of being removed from the body, it is called an *excretion*.

NOTE 48.

When Starch, Albumen, &c., are picked to pieces by the chemistry of the animal body, the Carbon, Oxygen, Hydrogen, and Nitrogen, of which they were composed, have a tendency to re-arrange themselves thus:—the Oxygen and Carbon unite as *Carbonic acid*, the Oxygen and Hydrogen as *Water*, and the Hydrogen and Nitrogen as *Ammonia*. *All* the excretions of an animal contain (besides Salts) and evolve, these three binary compounds, in different proportions.

Burning also, like animal life, *decomposes*, and into the same three substances, as was shewn in Section 1.

Note 49.

One of the many reasons which make it desirable to have plenty of green trees and shrubs growing in the heart of Towns (if only suitable ones are selected, and the fallen leaves are duly swept up), lies in the fact, that Plants not only, when in the sunlight, breathe out Oxygen, but also *manufacture Ozone* for us. This, which is regarded as "polarized or agitated Oxygen," is found in abundance in the atmosphere of country districts, but is scarcely recognisable in town localities. According to Professor Max Von Pettenkofer, "its presence can never be detected in our dwellings, not even in the cleanest and best ventilated." The fact is, that being, as Stevenson Macadam says, "the great Natural Disinfectant or Purifier of the air," it seizes hold of any noxious gas it meets with in its travels, and closing with it in mortal combat perishes in the moment of victory. "There is"—I quote a lecture by Dr. H. J. Alford—"more Ozone in the air when the barometer is falling than when it is rising, more on rainy days than on fine, and still more on snowy days. The proportion also varies with the direction of the wind."

Curiously enough too the minimum amount of *Carbonic acid* yet observed, viz.: 1½ in 10,000 parts of air, has been, (according to Dr. Wolffhügel) in a heavy snowstorm; while the maximum, nearly seven parts in 10,000, was in a very thick fog. It might seem surprising that there is no difference which can be detected as regards the proportion of this gas present, in the air of the sandy wastes, and of the oases, of the Libyan Desert. This phenomenon is attributed by the Munich Professor cited above to the "mobility of the air," and consequent distribution of its gases—"the average velocity of the air, with us" being, he says, "three metres [nearly 10 feet] per second, and even in apparent absolute calm more than half a metre."

The tests applied by Mr. Charles Pooley, of Weston-super-Mare, seem to indicate that the peculiar salubrity of that rising watering-place is really due, not, as was formerly supposed, to the Iodine of its famous "mud," but to the presence of an unusually large proportion of Ozone in its wind-swept atmosphere.

It is probable that both Ozone and Electricity assist, in the soil, in the preparation of Nitrogenous compounds for Plant-food.

Note 50.

"If," as Professor Max Von Pettenkofer reminds us, "the drainage of human habitations remains in soil *destitute of growing vegetation*, further decomposition sets in, and other processes are induced, not always of a salubrious nature, but often deleterious." The fact is that Earth *per se.*—even "dry" Earth—cannot in the fullest sense *disinfect*, it does but provisionally *deodorize and hold in suspense* the products of decomposition. The decomposition still goes on. That this is the case even with *Charcoal*, whose action in this direction is yet more powerful than that of Earth, has been demonstrated long ago by Dr. Stenhouse. It is only the action of the *Living and Growing Vegetable* which *re*-composes the products of *de*-composition, and carries out to its consummation the process of *Disinfection*, even as it is only through Plant-life that we can reach the goal of *Utilization*.

It is however maintained by an American writer, Mr. G E. Waring, that Charcoal, and in a less degree Dry Earth, not merely "absorbs foul-smelling odours but actually destroys them by slow combustion, so that the same mass of charcoal, or earth if kept dry and porous will continue almost indefinitely its undiminished *disinfecting* action." (N.B.—He does not define the term "disinfect.") He further states that "porous substances condense gases in proportion to the extent of their interior surface—the surface of the interior particles of a cubic inch of charcoal being equal to from 50 to 100 Square feet," and all of it engaged in concentrating the Oxygen which oxidises, and so "disinfects"—according to Mr. Waring—those gaseous products of putrefaction which are submitted to its action. That different sorts of charcoal absorb in different degrees has been shewn by Dr. Leared (in his work on "Indigestion") the palm, in this respect, being assigned to charcoal derived from the *densest* material from which charcoal is procurable, viz:—Vegetable Ivory.

ROBBINS, PRINTER, WESTON-SUPER-MARE.

TABLE OF CONTENTS.

PAGE.

Introduction 3

Section I.—Borrowing from the Air . 7

„ II.—Borrowing from the Soil . 14

„ III.—Indebtedness Admitted . 24

„ IV.—Transfer of Indebtedness from Plants to Man . . 30

„ V.—The Bill sent in to Man. . 38

Appendix 48

Notes 51

By the same Author.

Penny Tracts on Social Science,

VIZ.:

No. 1.—SOCIETY CLASSIFIED: in reply to the question, "How far is the Saying true, that Every one lives either by Working or by Begging, or by Stealing?"

No. 2.—THOUGHTS ON LUXURY AND POVERTY.

No. 3.—OUR MISDIRECTED LABOUR: considered as a grave National and Personal question, in regard to its Amount, Consequences and Causes.

OPINIONS OF THE PRESS, &c.

Mr. Ruskin (on No. 1):—"I beg all my readers to read with their best care the paper by Mr. Girdlestone. It is the most complete and logical statement of economic truth, in the points it touches, that I have ever seen in the English language."

The Rev. Prebendary Clark—referring, in "*Character and Work*," to Nos. 1, and 3:—"Valuable lectures"

The Freeman:—"Honest and able contributions to a discussion of the greatest importance."

Public Opinion:—"It would be a good thing for this country if provincial clubs were in the habit of listening to such sound common sense advice as these short addresses contain. The author is brief and eloquent, and his views are thoroughly practical."

The National Reformer—"The three essays are healthy and manly, and afford matter for thought"

The Monetary Gazett (on No. 1):—"Having carefully read it, we hail it as an evidence of progress of thought in the right direction."

The Bristol Daily Post (on No. 1):—"An ingenious and remarkable paper . . worthy the perusal of intelligent readers." (On No. 2):—"The arguments are set forth with great clearness and originality"

WESTON-SUPER-MARE: CHARLES ROBBINS, High Street.

LONDON: HAMILTON, ADAMS, and Co., Paternoster Row.